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SOLAR ECLIPSE PROBLEMS[1]

By Dr. J. H. MOORE

ASTRONOMER IN THE LICK OBSERVATORY

A TOTAL solar eclipse affords an opportunity to study the faint outer portions of the sun, invisible under ordinary conditions. Several serious attempts have been made to observe the solar corona without an eclipse, and although partial success has recently attended certain observations of this character we still are confined to the fleeting moments of totality for a study of its detailed structure. Moreover, at the time of a solar eclipse we are able to investigate most efficiently the spectrum of the chromosphere, and from such studies to obtain important information, not only concerning the distribution of the elements within the sun's atmosphere, but also of the physical conditions that obtain there. These two fields of research in solar physics may be regarded as preeminent among those associated with a total eclipse of the sun, and it is to certain of the problems related to the constitution of the chromosphere and the corona that I wish to direct your attention, stressing the observational more than the theoretical aspect.

[1] Address of the retiring vice-president and chairman of Section D—Astronomy, American Association for the Advancement of Science, Atlantic City, December, 1932.

THE CHROMOSPHERE

Immediately preceding and following totality when the glaring photosphere is hidden behind the moon's limb, the outer portion of the solar atmosphere appears as a narrow brilliant scarlet-colored crescent. To this envelope of the sun, Lockyer gave the name of chromosphere. Its spectrum was first observed at the eclipse of 1870 by Young, who found it to consist of bright lines on a dark background, which flash out as the photosphere is hidden, and remain for a few seconds, until covered by the advancing moon. This "flash spectrum" was regarded by Young as a reversal of the Fraunhofer lines whose origin was ascribed to

the "reversing layer," a shell of comparatively shallow depth, as shown by the brief duration of the flash.

Although numerous attempts were made to observe the spectrum of the chromosphere visually at succeeding eclipses, it was not until 1893 that the first photographs of the flash spectrum were secured by Fowler in West Africa and by Shackleton in Brazil. These observers employed prismatic cameras, a type of instrument admirably adapted to this particular problem, since the chromospheric crescent is so narrow that the slit of the spectrograph may be dispensed with. The spectrum recorded on the photographic plate consists of monochromatic images of the crescent in the different wave-lengths emitted by the chromosphere. Spectrographs of this form have generally been used in photographing the spectrum of the chromosphere at subsequent eclipses. Prism systems, of one, two or three prisms, or plane gratings, have been employed with camera lenses of various focal lengths, depending upon the region to be studied and the dispersion desired. Some observers have obtained beautiful flash spectra with the concave grating spectrograph in its slitless form. Photographs made in quick succession with an instrument of this type will record the changing spectrum at the sun's limb, Fraunhofer, flash and prominence spectra.

At the moment when the last vestige of the photosphere has disappeared the dark lines of the ordinary solar spectrum are replaced by the bright lines of the chromosphere, the lengths of the arcs being obviously an indication of the heights to which the various emissions can be traced. The majority of the lines are found at low levels and disappear at heights of only a few hundred kilometers, while a few, like those of helium, hydrogen and ionized calcium, ascend to heights of from 7,500 to 14,000 km.

While the procedure of recording the chromospheric spectrum, outlined above, appears to be quite simple, in practise it encounters certain difficulties. Aside from those common to most eclipse observations of adjusting and operating apparatus under trying conditions, there is the serious one of making the exposure at the proper time to obtain the fainter lines, which are visible for only about a second. This difficulty is obviated by the method devised by Campbell, in which the changing spectrum in a short central section of the crescent is recorded on a moving plate. The procedure consists in placing immediately in front of the plate a narrow slit parallel to the length of the spectrum, so that only a very short section of the crescent falls upon the sensitive film. The plate is then moved at a uniform rate behind the slit in a direction perpendicular to its length. By starting the exposure 25 or 30 seconds before second or third contact and continuing it for as many seconds after, a continuous record is obtained of the changing spectrum at the sun's limb from the Fraunhofer to the emission lines. The method was successfully employed by Campbell at the eclipses of 1898, 1900, 1905 and 1908. One of the chief difficulties he encountered with it was in obtaining a uniform motion of the photographic plate with the mechanical devices then available. Trouble from this source has been overcome at recent eclipses by driving the plate carriage by an electric motor of constant speed.

Spectrograms taken on the moving plate furnish a continuous record of the changes that take place in the spectral lines at only one point on the sun's limb as different levels of the solar atmosphere are covered or uncovered by the moon. On such photographs we note again the great heights shown by the lines of ionized calcium, hydrogen, helium, ionized strontium, the intermediate heights given by the lines of other atoms, generally in the ionized state, and the great number of the lines in the lower levels given for the most part by neutral atoms. One is impressed with the fact that while the spectrum of the chromosphere appears to be a reversal of the Fraunhofer spectrum, there are marked differences between the intensities of corresponding lines in the two spectra. The most pronounced dissimilarities are found in the enhanced lines or those that are given by ionized atoms, such lines being especially prominent in the chromosphere. Certain radiations appear in the flash spectrum that are not represented in the solar spectrum, while to some strong Fraunhofer lines there correspond only weak lines in the spectrum of the chromosphere. Most of these peculiarities that were once so puzzling, are now explained in a beautiful manner by the theory of ionization, first stated by Saha and developed in further detail by the contributions of Milne, Russell, R. H. Fowler, Eddington, and others.

Since the intensity of a spectral line depends upon the number of atoms acting in a given time to produce it, the relative number of atoms that are in the neutral and ionized states becomes a question of considerable importance in the interpretation of spectra. On the assumption that the general laws of thermodynamics apply equally well to electrons and molecules, Saha was able to calculate the degree of ionization that takes place in gases under different conditions of temperature and pressure. It was found that ionization is favored by increase in temperature or decrease in density of the gas, and that for different elements at the same temperature and pressure the degree of ionization is less for the one of greater ionization potential.

At the higher levels in the chromosphere the density must be much less than in those near its base, consequently the ionization is increased in spite of the somewhat lower temperature. The extension of the enhanced lines to heights greater than those of the

neutral atom and the strength of these lines in the flash spectrum is thus seen to be the result of decreased density within the chromosphere. The familiar lines of calcium furnish an interesting illustration of the point in question. The ultimate line of the neutral atom, g, or λ 4227, extends to a height of about 5,000 kilometers, while the H and K lines given by the ionized atom are visible to a height of 14,000 kilometers. Above 5,000 kilometers practically all the calcium atoms are ionized, leaving none to emit the lines of the neutral atoms, while the lines of the ionized atom appear as far up as the level where the chromosphere thins out entirely. Similar differences are found between the enhanced lines and those of the neutral atoms of strontium, scandium, titanium and other elements.

One might expect that the relative heights of the lines would correspond to the atomic weights of the elements, the greater heights being associated with elements of lower atomic weights. Calcium, however, with an atomic weight nearly twice that of sodium, can be traced to a greater height than either hydrogen or helium. This puzzling fact may be explained as the selective effect of radiation pressure. Above 1,500 km the sodium atoms are completely ionized, and the lines of ionized sodium lie in the far ultraviolet, where they are not observable. Ionized calcium, on the other hand, has strong ultimate lines in the visible region and so ascends to great heights.

Not only do the lines of greatest intesity, in general, reach the highest levels, but it is found that for any element the lines of greatest intensity and extending to the greatest heights in the chromosphere arise from multiplets of the lowest excitation potential. An interesting example of the relation of intensity and excitation potential is shown by the two pairs of Fe lines given by the neutral atom at λλ 3887.0 and 3886.3, and λλ 3878.0 and 3878.6. Though of comparable intensity in the sun, the second line of each pair is stronger in the flash, and arises from the lowest energy level in the atom, while the first ones come from the next higher level, with an excitation potential greater by only one volt.

This qualitative study of flash spectra has called attention to the fact that the heights to which the individual lines can be traced depends largely upon their intensities, which in turn are functions of abundance, atomic weight, ionization potential, excitation potential, etc.

A quantitative investigation of such spectrograms involves the determination of the wave-lengths, intensities and heights of the various spectral lines and is obviously a work of considerable magnitude. Studies of this character have been made by several investigators. Two of these have been published within the last two years, the one by S. A. Mitchell and the other by D. H. Menzel. Since they are the most extensive and thorough investigations of the flash spectrum that have been made, they merit our special attention at this time.

Mitchell's discussion is based largely upon his flash spectra obtained at the eclipses of 1905, 1925 and 1930, and includes the region from λ 3066 to λ 7065. His spectra were taken on a stationary plate, with a concave-grating spectrograph used in its slitless form. Menzel's results were derived from the Lick spectrograms taken without slit, the dispersion being given by prisms of flint or ultra-violet glass. These were supplemented by data obtained from spectra secured at the 1905 eclipse on fixed plates. The region of spectrum investigated by him was from λ 3229 to λ 5328.

Intensities of the chromospheric lines were estimated on the Rowland scale and for these the two observers are in satisfactory agreement. Their values for the relative heights of the high and low level lines, however, exhibit marked disagreement. Several explanations for this have been offered. The heights of the chromospheric vapors are derived from the angular length of the cusps on the stationary plate, while on the moving plate these heights are measured from a zero level somewhat arbitrarily chosen as the point where the continuous background seems to fade out. Moreover, these heights would be expected to be different, since they depend in part upon the speed of the spectrograph and of the photographic plate used. Differences arising from the choice of zero level, or from the speed of the recording apparatus, should not affect materially the relative heights of high and low level lines. The presence of a valley or mountain on the moon at the point of contact or near the ends of the cusps may readily give erroneous values of relative heights determined on the stationary plate, while lack of uniformity in the motion of the moving plate will produce similar errors. In order to check the uniformity in motion of the plate the second-breaks of a chronometer have been recorded on spectrograms secured by the method of the moving plate at recent eclipses. This is not the place to discuss the relative merits of the two methods of observing the flash spectrum; each has its own advantages and disadvantages. The record obtained by the one method offers a valuable check upon that of the other, and both were used by the Lick Observatory expedition at the eclipse of last August, as well as in 1905.

From the preceding discussion it will be evident that great caution should be exercised in drawing conclusions concerning apparent variations in the depth of the chromosphere from observations made at

different eclipses. Both Mitchell and Menzel have found evidence of such changes in chromospheric structure. On Mitchell's spectrograms of the 1905 and 1925 eclipses, taken with the same instrument, the lines of intermediate level are noticeably higher in 1925 than 1905, although no systematic difference is shown for the high level lines. Menzel's heights for the 1908 eclipse are uniformly lower than those derived from the 1905 plate. After careful consideration of all possible contributory factors, he is led to the conclusion that his observations indicate a real difference of height in the chromosphere at the two dates. In each case the greater heights were obtained at the time of greater solar activity, which is in harmony with what we should be led to expect from our present views of the structure of the chromosphere. More data, however, are needed before a variation of the character suggested can be considered as established.

Data of intensities and heights determined from flash spectra enable us to derive the distribution of the atoms at different levels, or the density gradient in the chromosphere. There are two independent methods by which this may be accomplished: (1) from the line intensities measured at different levels; (2) from the relation of the theoretical intensities of the members of multiplets to the heights of the corresponding lines. Menzel determined the relative intensities at six different levels in the chromospheric spectrum from microphotometer measures of the 1905 spectrogram. Laboring under the severe handicap of not having the characteristics of his plate defined by standard squares, he was forced to check his material from the interagreement of the data for different lines. The method of employing intensities at different heights along the spectral line, although apparently the most direct one for determining the density distribution, is complicated by the fact that the energy at a given level is the integrated light of this and the higher levels. It also becomes necessary to correct the observed intensity for the effect of self-reversal.

Both Mitchell and Menzel have used the second method of deriving the density gradient in the chromosphere up to a height of 2,500 km. The intensities of the members of a multiplet may be computed from the formulae relating the transition probabilities to the energy emitted by the different lines. It is then possible to derive a simple expression for the number of atoms per unit volume that are involved in the emission of a line of given intensity. From a knowledge of the heights to which the different lines of the multiplet extend in the chromosphere and the relative number of atoms concerned in the production of the lines, the relative concentration of the atoms at different levels may readily be obtained. In Menzel's discussion, all elements were grouped together, while Mitchell discussed the elements separately. Their results are in good agreement and show that the density gradient for the lower chromosphere is much less than would be expected in an isothermal atmosphere. It corresponds closely to that which would be given by an atmosphere of hydrogen in gravitational equilibrium, while at higher levels the chromosphere is even more distended. It is of interest to note in this connection that Menzel found the electron pressure at the base of the chromosphere to be about 10^{-7} atmospheres or about 500 times smaller than Russell's value for the pressure at the base of the reversing layer.

One of the most important fields of spectroscopic investigation is the determination of the energy emitted by a spectral line or the absolute intensity of the line. The problem on the experimental side is an extremely difficult one. Some progress, however, has been made by Unsöld and others for the strong resonance lines in the solar spectrum. Pannekoek and Minneart have attempted a similar investigation for the lines of the flash spectrum, utilizing for this purpose their high dispersion spectrograms secured at the eclipse of 1927. After calibration of the spectra through comparison with standard sources and elimination of the effects of instrumental and atmospheric absorption they were able to determine the absolute surface intensity of the chromosphere. The observed intensities for lines in well-known multiplets were compared with their theoretical intensities and found to increase more slowly than the latter. They interpret this as indicating an appreciable amount of self-absorption in the chromospheric layer when viewed tangentially. The density gradient for hydrogen deduced by them shows characteristics similar to those noted above.

The intensity of a spectral line, whether emission or absorption, is a function of the abundance of the element producing it. For an assembly of atoms in thermodynamic equilibrium the relation may be easily derived. Russell has, after making allowance for departure from thermodynamic equilibrium, utilized this relation in a most skilful investigation of the abundance of the various elements in the solar atmosphere, on the basis of the lines in the Fraunhofer spectrum. Since the intensities in the solar spectrum are estimated on an arbitrary scale, that of Rowland, it is necessary to reduce these to the scale based on theoretical intensities, before they can be used for determining the relative number of atoms engaged in the production of different lines. The calibration of Rowland's scale was obtained by comparison of the estimated and theoretical intensities of multiplets. Following Russell's procedure, both Mitchell and

Menzel have determined the abundance of the various elements in the chromosphere. The results show that for all the elements investigated, there appears to be little difference, except for hydrogen, between the relative abundance derived from Fraunhofer and flash spectra. Hydrogen seems to be considerably more abundant in the chromosphere than in the reversing layer.

By plotting the ratio of the number of atoms giving rise to multiplets in the reversing layer and chromosphere against the excitation potential of these lines Menzel finds evidence that the number of highly excited atoms in the chromosphere is greater than that predicted by the Boltzmann law. This excess, which increases with the excitation potential, is closely allied with the effect found by Russell and Adams from stellar spectra and generally known as the deviation of stellar atmospheres from thermodynamic equilibrium. In the chromosphere, however, it seems to be greatly intensified.

Determination of the temperature gradient in the chromosphere from the intensities and heights of the flash lines meets with certain difficulties, chiefly for the reason that the procedure of referring the observed intensities to the theoretical ones automatically corrects for possible temperature gradient. The observations afford some evidence that the mean temperature of the chromosphere is about 1,000 degrees lower than that of the reversing layer, and that the temperature gradient is low.

It appears then that the observed chromosphere lies above the layers that contribute the major portion of the absorption in the wings of the Fraunhofer lines, and that the chromospheric absorption accounts only for the central dark cores of some of the strongest lines. To this extent alone is the chromosphere the seat of Fraunhofer absorption.

The need for more observations of the flash spectrum is apparent. Spectrograms should be secured with both stationary and moving plates with as high dispersion as feasible and should be provided with photometric standards to permit of accurate calibration. The region of the infra-red is still a virgin field. The study of prominence spectra is also an important and closely related field of investigation which has been cultivated but slightly. A further investigation of the relation of the structure of the chromosphere to the cycle of solar activity is worthy of attention. Advantage should be taken of the excellent opportunity for securing spectrograms of the flash at a partial eclipse.

On the theoretical side important contributions to the problem of the structure of the chromosphere have been made by a number of investigators in an attempt to explain the small density gradient and the great heights to which the chromosphere extends. Milne has developel a beautiful theory of the equilibrium of an atmosphere of ionized calcium atoms supported by radiation pressure. It accounts for the high levels at which ionized calcium is found, and certain other phenomena of the chromosphere, but does not give the observed density gradient or emission of sufficient intensity. Moreover a chromosphere of the quiescent type postulated by the theory does not exist. McCrea and Rosseland have called attention to the effect of turbulence in the sun's atmosphere as an efficient aid in the support of the chromosphere. Pannekoek has shown that the electrons in an atmosphere, owing to their small atomic weight, would rise to great heights if they were not kept down by the attraction of the positively charged ions. This attraction, on the other hand, aids in keeping the ionized atoms at high levels. Menzel has made a careful discussion of the various theories and concludes that an extension of McCrea's theory to include the effects of self-reversal and Pannekoek's and Stewart's theories of electrostatic levitation gives a fair representation of the observed density gradient in the chromosphere and of the general featurs of the flash spectrum.

THE CORONA

From the brief review of the present status of certain problems relating to the structure of the chromosphere, it will be seen that real progress has been made toward a solution of at least a few of them. The situation with reference to the problems of the corona is less encouraging. Important facts concerning it have been established, but they are more or less isolated and in general their relations to each other are unknown. The paucity of results obtained thus far is due, primarily, to the unique condition that the opportunities for observing the corona are few and the time available for its study, at any one eclipse, is at best of but a few minutes' duration. Fortunate indeed would be the observer who could obtain an hour of totality with clear skies, in his entire lifetime.

Photography of the corona has comprised a part of the work of most expeditions that have observed total eclipses of the past fifty years. One of the most extensive series of coronal photographs is that obtained by eclipse expeditions of the Lick Observatory. These photographs were secured with cameras of various focal lengths, but since 1892 the more important observations of this character have been made with a form of photographic telescope designed by J. M. Schaeberle and used by him at that time in Chile. In this instrument the lens, of 5 inches aperture, remains stationary and the diurnal travel of the

sun is allowed for by moving the photographic plate in the focal plane of the lens. The photographs secured with it have generally been of excellent quality and reveal the intricate detail of structure, as well as the faint outer portions of the corona. The obvious advantages of large scale photographs of the corona have led other observers to employ cameras of even greater focal lengths.

At the eclipse of August 31, 1932, the responsibility for this part of the Lick Observatory program was undertaken by W. H. Wright. After careful consideration of the most advantageous form of instrument for coronal photography, he abandoned the 40-foot camera of the Schaeberle type for two photographic telescopes of 5 inches aperture and 15 feet focal length, rigidly mounted on a polar axis. The lenses are of excellent quality and are estimated to have about five times the speed of the 40-foot camera. This arrangement proved to be a very fortunate one at an eclipse where clouds were present, since it was possible to secure a greater number of photographs and to obtain a few of exceptionally long effective exposures. The superior quality of Wright's photographs fully supports the wisdom of his choice of instruments. When enlarged to the scale of those taken with the 40-foot camera they are equal, if not superior, in the excellence of their definition and in the delineation of coronal detail.

Photographs of the corona secured in this manner, although subject to the limitations of a composite picture of structural detail at different positions along the line of sight, afford a basis for study of the general form and structure of the corona.

It has long been known that the shape of the corona near the time of maximum in the sun-spot cycle is different from that near minimum sun-spots. The type of corona associated with sun-spot maximum is approximately circular in form, while that near minimum is roughly rectangular with the polar brushes and wing-like extensions at lower latitudes in which the sun-spots and prominences are found. Ludendorff has devised a simple method of representing more precisely the form of the corona through the ellipticity of lines of equal intensity drawn on coronal photographs. Studies made by him in this way, of the coronas from thirteen eclipses secured at different phases in the sun-spot cycle, reveal a closer relation between the coronal shape and the actual number of spots visible for a few days preceding and following the date, than with the phase in the solar cycle. From a study of the coronas observed since 1860, Lockyer has found a close correlation between the shape of the corona and the position of the prominences, the maximum type occurring when prominences are near the polar region.

Examination of the individual details in the corona has revealed a connection in some cases between the long streamers and prominences visible at the limb. The structure of the inner corona is affected to a marked extent in the neighborhood of prominences. On the other hand, in only a few instances has it been possible to trace a direct connection between disturbed areas in the corona and large spots, or groups of spots, visible near the sun's limb. "Arches," "hoods" or "striated cones" are marked features of the inner and middle corona and are especially conspicuous near sun-spot maximum. In most instances, they are found to be erected over a large prominence and their forms suggest that the coronal materials are being driven outward from the prominence. That such is the case was found by Miller, who compared large scale photographs of the corona in 1918, taken at three separate stations, those of the Lick, Lowell and Sproul expeditions. Measures were made on three arches surrounding three conspicuous prominences. These gave fairly accordant results and indicated that in the twenty-six minutes that elapsed between the times of the Lick and Sproul photographs the arches had receded from the sun, with an average speed of about ten miles per second. Other attempts to detect motion of the coronal details on direct photographs taken at one station or by comparing those from widely separated stations have yielded little more than the result that, for the most part, the motion is small.

Progress in acquiring information about the spectrum of the corona has been painfully slow. The reasons are not far to seek. The coronal spectrum is very weak and the opportunities for observing it are few. The inner corona, up to about ten minutes of arc from the sun's limb, gives a continuous spectrum upon which are superimposed a number of bright lines extending to distances of from 5′ to 10′ from the sun. With the possible exception of the strong red line at λ 6374, none of these have been observed in laboratory spectra or in those of the stars or nebulae. About 42 coronal emission lines in the region λ 3164 to λ 6800 have been reported by various observers but in the case of half of these it is extremely doubtful whether they are of coronal origin. The strongest lines are the well known one in the green, λ 5303, and the ultra-violet line, λ 3888. Next in intensity are $\lambda\lambda$ 6374, 3601, 4231, etc. The wave-lengths of but a few are known to a tenth of an angstrom, those of λ 5303 and λ 6374 being the most accurately determined.

Although the slit spectrograph is superior to the slitless form for wave-length determinations, spectrograms obtained with the latter instrument yield information of the greatest value concerning the dis-

tribution of intensities in the coronal emissions. The radiation in a single line is found to have very different intensities in different parts of the inner corona. The coronal ring exhibited by λ 5303, for example, is very faint in the polar regions and even at lower latitudes shows a marked variation in intensity. At the eclipse of 1918, this radiation was strengthened near the bases of the prominences and had its greatest intensity near the eruptive prominence at the southwest limb of the sun. Similar effects are to be seen in the green coronal ring obtained at the eclipse of last August, its greatest strength being shown near the two prominences on the west limb, while it was extremely faint over the whole east limb. On the same spectrogram the coronal ring in λ 6374 shows a more uniform distribution than λ 5303, although it, too, is weak in the polar regions and of greatest strength near the prominence on the southwest limb. In other details the distribution in the two radiations shows great dissimilarity. This difference, noted also by other observers, indicates that the two radiations can not take their origin in the the same atom in the same state of ionization.

Studies of the distribution of the intensities exhibited by the different coronal radiations enable us to group together lines of like behavior and should prove an important aid in the identification of the atom, or atoms, responsible for these emissions. Some of the stronger coronal lines have been so grouped by several observers, but there is a manifest disagreement in their opinions in this matter. At present, there seems to be reliable evidence that λ 3601 and λ 4086 belong together and that λ 5303 and λ 3388 form a pair, but the data for the others are not sufficient to permit their classification.

The great variation in intensity of the emission in different parts of the corona obviously limits the value of line intensities derived from spectra secured with a slit spectrograph and also accounts to a large extent for the failure to observe certain lines at one eclipse, which were obtained in good strength at another. To this cause may be ascribed some of the observed variation in the green line shown by comparing slit spectrograms of different eclipses, although there seems to be some evidence that this line is stronger near sun-spot maximum than near the minimum in the cycle. One of the most fruitful fields of coronal spectroscopy is undoubtedly that of the investigation of the forms, intensities and structural details in the coronal rings obtained with slitless spectrographs of fairly high dispersion.

Several observers have attempted to study the green line with an interferometer of the Fabry and Perot type, but without success. At the eclipse of last August, Shane made use of a slit spectrograph provided with an etalon of 2.5 mm separation and obtained very weak interference fringes in the green line. The observation is of importance not only because it explains the failure of previous attempts in which higher orders of interference were used, but also because it gives definite indication as to the width of the line. This, Shane estimates to be of the order of one third of an angstrom. The observed width of the line is probably due to the effect of turbulence in the inner corona.

A number of suggestions have been made as to the atom giving the coronal emissions. Pannekoek once suggested that they were due to doubly ionized calcium. Freeman, from coincidences in wave-length, attributed them to argon, while Rosenthal attempted to identify them with radiations of the helium atom in a special state. None of these identifications are entitled to any weight. Recently Hopfield has called attention to an unclassified line in the spectrum of oxygen, having wave-length 6374.29 A. and in close agreement with that of the red coronal line 6374.28 A. de Bruin has calculated three additional lines in the spectrum of neutral oxygen which he identifies with λ 5303, λ 6704 and λ 6775, but here again the identification appears to be open to serious criticism, so that the great mystery of the coronal lines still remains unsolved.

Many attempts have been made to study the corona without an eclipse, but until recently all have ended in failure. One of the most important advances in the investigation of the inner corona made in recent years is that due to Bernard Lyot, who, in full sunlight, obtained the red and green lines with his spectrograph and determined their wave-lengths. Moreover, with a spectroheliograph he photographed the inner corona in light of these two radiations. It is well known that the great obstacle standing in the way of observations of this character is that of the light scattered by the atmosphere and by the image-forming lens. By working at the observatory of Pic du Midi at an altitude of 2,870 meters, he reduced to a minimum the scattering of light by particles suspended in the air. A carefully ground simple lens was used to obtain the image, the light scattered by it being excluded through use of properly arranged diaphragms. Only by careful attention to the elimination of every possible source of scattered light in his instrument was success finally attained. The possibilities offered by this method to astronomers at mountain observatories for studies of coronal radiation, without the necessity of waiting for a total eclipse, are certainly alluring.

The spectrum of the corona beyond 8′ to 10′ from the sun's limb exhibits the Fraunhofer lines of the solar spectrum. The relative intensities of the coronal

lines seem to be quite similar to those of the sun's spectrum. They have, however, a hazy appearance which is doubtless due to the fact that they record light scattered by different portions of the corona in the line of sight. That the Fraunhofer spectrum of the corona is caused by the scattering of sunlight by coronal material in a finely divided state is substantiated by the fact that the light of the corona is polarized. Measures by R. K. Young of the photographs obtained with polarigraphs by Lick observers show that the polarization is radial and that the percentage of polarized light increases rapidly from the sun's limb, reaching a maximum of 37 per cent. at a distance of 5′, and then diminishes slowly as the distance from the limb increases.

On the spectrograms secured in 1922, I measured the positions of the Fraunhofer lines in the coronal spectrum at points east and west of the sun and found that these were displaced toward the red with reference to the ordinary solar lines. The displacements, interpreted as a Doppler-effect, indicate radial motion of the coronal particles at points 20′ east and west of the sun's limb of about 12 or 15 miles per second, a speed of the same order as that found by Miller. These results are subject to considerable uncertainty on account of the character of the spectra measured. For this reason an attempt was made to repeat the observations at the eclipse of last August, with spectrographs especially designed for this particular problem. Unfortunately, the value of the spectrograms secured is somewhat impaired by the effect of scattered light from the clouds covering the sun during totality. Preliminary measures of these plates indicate the presence of small displacements in the Fraunhofer lines of the corona east and west of the sun, corresponding to a velocity of recession of about ten miles per second. At present we have no reliable information concerning the rotation of the corona.

Our knowledge of the total light of the corona and the distribution of its intensity with distance from the sun is still in an unsatisfactory state. The most reliable information we have at present, concerning the total brightness of the corona is to the effect that it is about 0.50 that of the full moon, although it probably varies with the cycle of solar activity. Observations of this character are beset with numerous difficulties but those made by recent investigators give evidence that many of them have been overcome. A most thorough investigation of the distribution of coronal intensity with distance from the sun was made by Bergstrand, who brought to this problem many years of experience in the methods of photographic photometry. He found that the intensity of coronal light in the photographic region varies inversely as the square of the distance from the sun's surface. Other observers have derived the law of variation to be according to the fourth, sixth, seventh and eighth powers.

Of coronal theories there is a sufficient number to permit of choice according to the particular phase of coronal studies in which one happens to be interested. Mechanical, electric, magnetic and other theories have been suggested, but in the present state of our knowledge with respect to the phenomena of the corona, it would not be profitable to give serious consideration to any of them. A corona composed of electrons and ions will account for many of the phenomena, especially those associated with its radiation. While there is much to commend the theory, it too meets with its share of difficulties.

The problems of the structure of the chromosphere and the corona are many and the solutions for a number of them are still to be given. Most encouraging progress has been made in unraveling the structure of the chromosphere, largely through the aid of the recent developments in our ideas of the behavior of the atom under different conditions and the manner in which it radiates energy. Regarding the corona our knowledge is in a less advanced state, but the time is not far distant, in my opinion, when many of its complex phenomena will receive a satisfactory interpretation.

OBITUARY

ACHILLES DE KHOTINSKY

ON March 28, 1933, occurred the death, in Pentwater, Michigan, of Captain Achilles de Khotinsky, who, through his genius in invention, design and construction, leaves a permanent impression on physics and chemistry in America. Captain de Khotinsky was born on January 6, 1850, in St. Petersburg, Russia. Having completed the course in the Imperial Naval Academy, he spent the next 13 years in the Russian navy, in which he attained the rank of captain. It was during this period, in 1878, that he first saw America, while on commission to supervise the construction of three battle cruisers for the imperial navy. In the late seventies he obtained European patents on incandescent lamps which he manufactured on a large scale in Russia, Germany, Austria, England, France and Holland. He also held a basic French patent on the pasted storage battery plate. While in England, he developed the widely used de Khotinsky cement, known to every research physicist as indispensable in investigations involving vacuum technique.

Returning to America in 1891, he established an incandescent lamp factory in Massachusetts. As a result of patent difficulties, the plant was closed after about a year of operation. Deprived of practically all he possessed, he came west, spending about a year at Purdue University. In the middle nineties he located at Chicago. During the next twenty years he was associated with various firms and institutions, among them the Western Electric Company, Wm. Gaertner and Company, Armour Institute of Technology and the University of Chicago. Many physicists and chemists who obtained their degrees from Chicago will affectionately recall "the Captain," as he was always known to his associates and acquaintances. He spent eight years with Professor Michelson at Ryerson Laboratory, designing and constructing research apparatus and ruling diffraction gratings, after which he spent some years in Kent Laboratory as research mechanician. In 1916 he joined the development staff of Central Scientific Company, where he remained until 1922. Here he developed miscellaneous constant temperature devices, including ovens, water baths and thermoregulators. His contributions to design and production methods of military instruments which the company manufactured for the government during the war were numerous.

In 1922 Professor Randall, of the University of Michigan, asked the writer to suggest some one who might undertake the design and construction of a dividing engine for ruling special diffraction gratings, to be used in researches in the region of the longer wave-lengths. No one seemed better qualified than Captain de Khotinsky. Although 72 years old at that time, he was happy for the opportunity of spending the next few years in the kind of work he loved and in most congenial and pleasant surroundings. In three years the ruling machine was completed and in operation. Not the smallest part of his achievement was the method of shaping the diamond ruling points to produce grooves of predetermined shape, by means of which intense spectra in selected wave-length regions could be obtained.

In 1926 Captain de Khotinsky retired to Pentwater, to spend his declining years.

His achievements are numerous. In engineering he has to his credit many inventions and patents on incandescent lamps, storage battery plates, and automatic gun-firing devices. He devised the first switchboard signal lamp. In physics he is best known for his de Khotinsky cement and his work in the production of diffraction gratings, while chemists and bacteriologists will remember him for his laboratory devices for the maintenance of constant temperatures.

PAUL E. KLOPSTEG

RECENT DEATHS

DR. JERMAIN GILDERSLEEVE PORTER, professor of astronomy at the University of Cincinnati and director of the Cincinnati Observatory from 1884 to 1931, died on April 15 at the age of eighty-one years.

MRS. ZELIA NUTTALL, honorary special assistant at the Peabody Museum of Harvard University and honorary professor of archeology at the National Museum of Mexico, died at her home in Mexico City on April 12, in her seventy-fifth year.

THE death is announced of Dr. Ernst Grossmann, professor of astronomy at Munich.

THE Duke of the Abruzzi, who conducted explorations in Africa, India and the far north, died on March 18, aged sixty years.

JULES PICCARD, for forty years professor of chemistry at Basle, died on April 11. Dr. Piccard was the father of Dr. Auguste Piccard, professor of physics and physical measurements and director of the laboratory of physics at the University of Brussels, who is now visiting the United States.

SCIENTIFIC EVENTS

THE EIGHTIETH ANNIVERSARY OF THE FOUNDING OF THE CALIFORNIA ACADEMY OF SCIENCES

ON April 4, the eightieth anniversary of its founding was celebrated by the California Academy of Sciences in its Simson African Hall, where a preview was arranged of the installations of habitat groups of African mammals which are now in a stage of particular interest. At this function, there was a brief address of welcome by Mr. William H. Crocker, the president of the Board of Trustees, who has held this position since 1897. Dr. C. E. Grunsky, president of the academy for over twenty-one years, referred briefly to the history of the academy as a scientific research and educational institution, whose activities since its inception have been made possible by generous contributions and endowments from private individuals, outstanding among which is that of James Lick some sixty years ago. The Lick endowment placed the academy in unrestricted ownership of downtown property in San Francisco, the improvements on which, made with borrowed money, yield most of the income which makes its activities possible.

When Mr. Leslie Simson some years ago made his offer to furnish to the academy, free of cost, specimens of African mammals which would be needed for

an African hall of habitat groups, provided that a house for the collection were provided, it was hoped that some one might come forward with an endowment for much needed new buildings. But this did not happen. Mr. Simson then offered to the academy property worth $150,000, but with the condition that income therefrom should be his during life. His proposition was accepted and the academy borrowed $255,000 and erected a new unit to its museum buildings in Golden Gate Park in which it has provided space for the departments of entomology and ichthyology, for the administrative offices, and for the Simson African Hall.

In this hall, under the direction and general planning of Mr. Frank Tose, the chief of exhibits, the habitat groups are being installed. There will be ten large groups, thirteen intermediate small size groups and one very large waterhole group at the end of the hall. Of these groups, only one is now under glass. The backgrounds of three small groups have been painted and the backgrounds of five other large groups are nearing completion. The lighting of the habitat groups will all be artificial. Their backgrounds are domed so that all structural work is concealed. The observer gets no impression of a painted wall. Glass fronts will be inclined so that reflections of opposite light areas will be thrown well up above the horizon where they will interfere least with a view of the mounted specimens. In the lion group, the preparator of which throughout is Mr. Tose, sunlight effect by a transparency behind a rugged foreground is startling and exceptionally realistic, made to merge perfectly into the surrounding well-lighted surface painting.

It is notable in connection with this installation that there are no lighting fixtures in the hall. Abundant indirect light radiates from the habitat groups, all of which are artificially illuminated.

The hope was expressed that sponsors would be found for the individual habitat groups, as has been the case in the academy's hall of California wild life.

THE NEW COMMISSIONER OF INDIAN AFFAIRS

JOHN COLLIER has been nominated by President Roosevelt to succeed Charles J. Rhoads as Commissioner of Indian Affairs. In making the announcement Harold L. Ickes, Secretary of the Interior, made the following statement:

> John Collier will bring to the administration of the Bureau of Indian Affairs a wide knowledge of the subject based upon personal contacts and intensive study during the past several years. In my judgment, he is the best equipped man who has ever occupied that office.
>
> Drafted by the government four years ago, Mr. Charles J. Rhoads has served as Commissioner of Indian Affairs with great distinction. His uprightness of character, his ability and his single-hearted desire to serve have impressed all who have known him and realized the difficult task he undertook. It has been my pleasure to know Mr. Rhoads and the fine work he has done. Respecting his repeated request to be permitted to retire to private life, a conscientious effort has been made to find an outstanding and experienced man to take over his burdensome duties. Such a man I believe Mr. Collier to be.
>
> I am deeply concerned about the welfare of the American Indians. I am persuaded that they are entitled to every consideration that the government can give them. The Commissioner of Indian Affairs ought to be the representative of the Indians themselves in the Department of the Interior. He should be their advocate, fighting for their interests and pleading their cause. Those who seek to encroach upon the rights and privileges of these original Americans are amply able to look out for themselves. Unless the government selects the right kind of a man as Commissioner of Indian Affairs, the Indians themselves are, in effect, without a friend at court when substantial rights and interests of theirs are up for adjudication.
>
> I have known John Collier for a number of years, and I have had opportunity to acquaint myself at first hand with the soundness of his views and his attitude toward the Indian question. In addition to safeguarding the property rights of the Indians, he will help them to help themselves toward a fuller and happier life. He will respect their customs, encourage them in their arts and assist them to maintain their rich and unique culture. He will try to interpret them sympathetically to their white fellow Americans. He realizes that on the purely material side, our American Indians possess possibilities in which the white people themselves may share, if those possibilities are realized and cultivated.

IN HONOR OF CHARLES E. MUNROE

AT the subscription dinner at the recent Washington meeting of the American Chemical Society Dr. Charles E. Munroe, past president of the society and its only surviving charter member, was the guest of honor. In testimony of the esteem of the society, Dr. Munroe was presented with a jeweled emblem of the society and a purse. In presenting these tokens, Dr. Arthur B. Lamb, professor of chemistry and director of the laboratory at Harvard University, president of the society, said, in part:

> The American Chemical Society was definitely organized on April 20, 1876, in New York City. Of the one hundred and thirty-three charter members at that time the sole survivor to-day is Charles Edward Munroe.
>
> The first general meeting of the society was held in Newport, Rhode Island, on August 6 and 7, 1890, at the suggestion and under the chairmanship of Dr. Munroe, who was at that time a member of the technical staff of the United States Navy Torpedo Station at that city. Dr. Munroe was president of the society in 1898 to 1899 and is honorary chairman of this, the eighty-fifth general

meeting of the American Chemical Society. He is with us here to-night, as keen of wit and as full of energy, optimism, kindness and good will as when he assisted in the establishment of our society fifty-seven years ago!

Dr. Munroe was born in Cambridge, Massachusetts, in 1849. He graduated from the Lawrence Scientific School at Harvard in 1871 and stayed on as instructor in quantitative analysis in the chemical department of the university until 1874.

From Harvard, Dr. Munroe went as professor of chemistry to the Naval Academy at Annapolis. After twelve years there he became chemist to the Torpedo Corps, United States Naval Station, and War College, and to other bureaus of the Federal Government; and thereafter, professor of chemistry and dean of the graduate faculty of George Washington University. He is the inventor of smokeless powder, discoverer of the "Munroe Effect," and author of a hundred or more articles and books on chemistry and explosion.

But as Dr. Wiley has said, Dr. Munroe's greatest works are not found in the scientific papers that he has published nor in the dangerous researches that he has made, but in the hearts and lives of the thousands he has taught.

Dr. Munroe, as I have said, was born in 1849. Gold was discovered that year in Cambridge as well as in California—for Dr. Munroe's heart is made exclusively of that noble metal!

It is then with the greatest pleasure and satisfaction that I hand to you, Dr. Charles Edwin Munroe, first, this gold pin carrying the emblem of our society, and secondly, these gold certificates of the United States Treasury, as tokens of our respect, our admiration and our affection.

THE AWARD OF THE WILLARD GIBBS MEDAL TO DR. RICHARD WILLSTAETTER

DR. RICHARD WILLSTAETTER, of Munich, who received the Nobel Prize in 1915, has been awarded the Willard Gibbs Medal of the Chicago Section of the American Chemical Society.

The award is made for Dr. Willstaetter's work in chemistry, especially in the chemistry of chlorophyll. His name is added to the list of twenty-one other Willard Gibbs medalists "whose work in either pure or applied science has received world-wide recognition." The jury which voted the medal consisted of twelve American leaders representing every branch of chemistry.

The medal will be conferred on Dr. Willstaetter in Chicago on September 13 during the eighty-sixth meeting of the American Chemical Society, which will be held in connection with the Century of Progress Exposition. A distinguished group of scientists from Europe and America will witness the ceremony.

A statement from the American Chemical Society says:

Dr. Willstaetter is known for his researches in organic chemistry, particularly in biochemistry. The chronicle of his career in science is the record of a great mind successfully attacking, in logical sequence, some of the most difficult problems in organic and bio chemistry.

The greatness of Dr. Willstaetter as a chemist lies not only in his signal accomplishments, but in his ability to perpetuate his influence by opening the way for the work of others. He has conquered barren wildernesses of ignorance and left them fertile fields where others as well as himself might gain rich reward.

Honored by scientific societies all over the world for his contributions to the field of organic chemistry, Dr. Willstaetter last year was awarded the Davy Medal of the Royal Society in London. His sixtieth birthday last August was widely celebrated in Germany.

One of the best known of all European chemists, Dr. Willstaetter's first great independent research was with the cocaine alkaloids, the result of which "set the field in order" and culminated in the synthesis of cocaine. Next he attacked the quinines and quininoid substances, and discovered ortho-quinine and proof of the structure of aniline black.

Work on the cyclic hydrocarbons, important in the oil industry, was the next step in Dr. Willstaetter's scientific career, the most notable achievement in this field being the synthesis of cyclo-octatetrene, a cyclic substance having alternating single and double bonds, but not aromatic in nature.

An outstanding chapter in Dr. Willstaetter's studies was his investigation on the structure of chlorophyll, the green coloring matter of leaves which is present in all growing vegetable cells, and the assimilation of carbon dioxide by plants. He proved the identity of chlorophyll from many plants, demonstrated the existence of two chlorophylls, and their close association with the carotinoids, a widely distributed plant pigment.

From products derived after breaking down chlorophyll, Dr. Willstaetter disclosed most of the secrets of its structure, thus contributing greatly to science's knowledge of the vegetable kingdom. His researches with the anthocyanins, flower pigments, demonstrated the close relationship of this varied-hued substance to chlorophyll, and the simple means by which nature changes the blue of the cornflower to the red of the rose or the purple of the grape. This study of plant pigments was crowned in 1915 by the award of the Nobel Prize for outstanding chemical research.

Dr. Willstaetter next considered the related field of the enzymes, chemical compounds of vegetable or animal origin that cause chemical transformation. By developing new methods and by insisting upon checking each procedure through quantitative analysis, he revolutionized research in this field.

Valuable contributions on many other subjects, such as hydrogenation with platinum and the hydrates of metals, have been made by Dr. Willstaetter, in addition to his major researches. In most cases these lesser studies grew out of the need for information to assist some

principal experimental procedure. These investigations have been found to be so numerous that there is "scarcely a phase of organic chemistry in which one can read far without encountering Willstaetter's name."

Dr. Willstaetter's work with the cocaine alkaloids made possible the commercial synthesis of local anesthetics. His studies in chlorophyll paved the way for the triumphs of Professor Hans Fischer, at Munich, and Professor James Bryant Conant, at Harvard, in this field.

Dr. Willstaetter's experiments with the carotinoids have made possible the separation of the individual components of this group and their relation to Vitamin A, while his researches in the enzymes "lifted the veil that obscured the complex processes of protein hydrolysis."

SCIENTIFIC NOTES AND NEWS

ACCORDING to press dispatches, Dr. Albert Einstein has accepted "with the greatest pleasure and gratitude" a professorship in the University of Paris. It is said that the professorship is at the Sorbonne, but it is also reported that the French government has proposed to establish a chair of mathematical physics for him in the Collège de France. It is understood that this new appointment will not interfere with Dr. Einstein's professorship in the University of Madrid or with appointments that he has accepted in Brussels and Glasgow. Dr. Einstein will return to the United States in the autumn to occupy for part of the year the chair of mathematical physics in the Institute for Advanced Study at Princeton.

THE Trustees of Princeton University announce the retirement of Dr. Edwin Grant Conklin, professor of zoology; of Dr. Charles F. W. McClure, professor of comparative anatomy, and of W. B. Harris, professor of geodesy. They will continue their connection with the university as lecturers. The resignation of Professor Augustus Trowbridge, dean of the graduate school, on account of ill health, is also announced. Professor Edmund Newton Harvey, professor of physiology, has been assigned to succeed Dr. Conklin in the Henry Fairfield Osborn professorship of biology, and Professor Wilbur Willis Swingle has been appointed to the Edwin Grant Conklin professorship of biology.

DR. MORTIMER E. COOLEY, dean emeritus of the College of Engineering and Architecture of the University of Michigan, celebrated his seventy-eighth birthday on March 28. During the day Dr. Cooley received his colleagues and friends in his room at the Engineering Building.

DR. FRANK A. HARTMAN, professor of physiology at the University of Buffalo, has been awarded the Schoellkopf Medal for 1933, for his work on cortin. This medal is bestowed annually by the western New York section of the American Chemical Society for outstanding achievement in science.

THE Joseph A. Capps Prize for 1932 of the Institute of Medicine of Chicago has been awarded to Eugene L. Walsh, Northwestern University Medical School, 1931, for his "Studies on the Etiology of Gallstones." Dr. Walsh holds the George W. Belcher fellowship in urology at the Cleveland Clinic Foundation. Honorable mention was given to Edward E. P. Seidmon, University of Illinois College of Medicine, 1932, for his paper on "Influence of Vitamin Deficient Diets upon Intestinal Acid-base Equilibrium." The Joseph A. Capps Prize of $500 is awarded annually for meritorious medical research by a graduate of a medical school in Chicago completed within two years after graduation.

DR. THEODOR WIEGAND, Berlin, president of the Imperial Archeological Institute, has been made an honorary doctor of the medical faculty of the University of Berlin.

DR. VICTOR GOLDSCHMIDT, of Heidelberg, has been elected an honorary member of the German Mineralogical Society.

THE Makdougall-Brisbane Prize of the Royal Society of Edinburgh for 1930–32 has been awarded to Dr. A. C. Aitken, of the University of Edinburgh, for contributions to mathematics published in the *Proceedings* of the society, and the Gunning Victoria Jubilee Prize for 1928–32 to Sir James Walker, for work in physical and general chemistry.

THE *Journal* of the American Medical Association reports that three hundred and seventy-five friends of Dr. Howard A. Kelly, Baltimore, gathered at a dinner on February 20, in celebration of his seventy-fifth birthday. Dr. Thomas S. Cullen, Baltimore, was toastmaster, and speakers included Dr. Walter W. Chipman, emeritus professor of obstetrics and gynecology, McGill University, and Dr. Abraham Flexner, director of the Institute for Advanced Study, Princeton. A special tribute was sent to Dr. Kelly by Dr. William H. Welch, emeritus professor of the history of medicine at the Johns Hopkins University School of Medicine, who, since February 1, has been a patient in the Brady Clinic, Johns Hopkins Hospital. Dr. Kelly, who is known as the "father of gynecology," is professor emeritus of gynecology at Johns Hopkins, with which he has been associated since 1889, retiring from active work at the school in 1919.

DR. WILLIAM H. PARK, general director of the Bureau of Laboratories of the Department of Health of

New York City, professor of bacteriology and hygiene at New York University and professor of preventive medicine at Bellevue Hospital Medical College, was the guest of honor at a dinner given at the Biltmore on April 19 by his friends and associates. The date was the fortieth anniversary of Dr. Park's founding in New York of the first public bacteriological laboratory in the world. Dr. Linsly R. Williams, director of the New York Academy of Medicine, was chairman of the dinner committee and Dr. Shirley W. Wynne, Health Commissioner, was toastmaster. The speakers included, in addition to Dr. Williams, Dr. Matthias Nicoll, Homer Folks and Dr. C.-E. A. Winslow.

WE learn from *Nature* that at the annual general meeting of the Institute of Metals, the following officers were elected for the year 1933–34: *President,* Sir Henry Fowler; *Vice-presidents,* Professor C. H. Desch and Professor R. S. Hutton; *Members of Council,* Eng. Vice-Admiral Sir Robert Dixon, Mr. Wesley Lambert, Mr. H. C. Lancaster, Mr. A. H. Mundey, Mr. A. J. G. Smout, Mr. F. Tomlinson. The silver jubilee meeting of the institute will be held in Birmingham from September 18 to 21. It was in Birmingham that the first general meeting of the institute was held in the autumn of 1908, under the presidency of the late Sir William White.

DR. HARRY A. CHARIPPER, assistant professor of biology at the Washington Square College of New York University, has been appointed head of the department.

MARGARET M. FULFORD, of the department of botany of the University of Cincinnati, has been appointed curator of hepatics and a member of the advisory board of the Sullivant Moss Society.

WORK at the new Leonard Wood Laboratory for the Eradication of Leprosy on Culion Island, the Philippines, is planned by Dr. Malcolm H. Soule, University of Michigan; Dr. E. B. McKinley, George Washington University; Dr. E. W. Goodpasture, Vanderbilt University; Dr. E. R. Long, University of Pennsylvania; Dr. T. M. Rivers, Rockefeller Institute, and Dr. Hans Zinsser, Harvard University. A correspondent writes: "Recently Drs. Soule and McKinley succeeded in isolating the leprosy bacillus, or germ, outside the human body. Monkeys inoculated with the bacillus developed conditions suggestive of the human disease, but soon recovered. Other laboratory animals failed to show any signs of the disease. Drs. Soule and McKinley have been granted leave of absence from June next to February, 1934. They will be the first of the group who within the next few years will endeavor to work out preventive treatment and, if possible, a cure for the disease."

DR. SVEIN ROSSELAND, director of the observatory at Oslo, has arrived at the Massachusetts Institute of Technology to make an intensive study of the differential analyzer designed by Dr. Vannevar Bush, vice-president of the institute and professor of electrical power transmission.

PROFESSOR OTTO HAHN, director of the Kaiser Wilhelm Institute in Berlin, non-resident Baker lecturer at Cornell University, will deliver the second John Howard Appleton Lecture at Brown University on April 28. His subject will be "The Radioactive Elements and their Application in Chemical Research."

DR. OTTO LOEWI, professor of pharmacology at Graz, will deliver at 5 o'clock on May 4 and 11 the Edward K. Dunham Lectures for the promotion of the medical sciences at Harvard University. The subjects of the lectures are "Humoral Transmission of the Nerve Impulse" and "Regulation and Adaptation."

DR. FELIX BERNSTEIN, director of the Institute of Mathematical Statistics of the University of Göttingen, spoke before the Sigma Xi Chapter of the University of Cincinnati on April 10 on "Solution of Mathematical Problems in Physics and Engineering by New Mechanical Means."

PROFESSOR H. J. MULLER, of the University of Texas, lectured at the University of Stockholm on April 4 on "Evolution in the Light of the Modern Mutation Theory." On April 6 he lectured at the University of Oslo, on April 8 before the Mendelian Society of Lund and on April 11 at the University of Copenhagen. He is to address the Genetical Society of London on April 27.

PROFESSOR A. E. KENNELLY spoke on April 11 on "Experiences during the Development of Electrical Engineering since the Year 1875," before a joint meeting at Harvard University of the Boston Section of the American Institute of Electrical Engineers with the Student Branches of Harvard University, Massachusetts Institute of Technology, Northeastern University and Tufts College.

THE program of illustrated lectures arranged by the California Academy of Sciences during April and May, at San Francisco, under an endowment by an unnamed friend, is announced as follows: "Natural and Cultural Pearls," Dr. Charles A. Kofoid, professor of zoology, University of California; "Explorations in Plant Life," Arthur C. Pillsbury; "Crystals and Crystallization," Dr. Austin F. Rogers, professor of mineralogy, Stanford University, and "Some Protozoa and Causes of Disease in Animals and Man," Dr. Charles A. Kofoid, professor of zoology, Uni-

versity of California. These lectures are free to the public.

THE Pennsylvania Topographic and Geologic Survey has recently moved its offices from the Claster Building on Market Street in Harrisburg, Pennsylvania, to the sixth floor of the South Office Building of the Capitol group. The scientific staff and its special interests now is as follows: George H. Ashley, state geologist, coal; Ralph W. Stone, assistant state geologist, structural materials; Stanley H. Cathcart, associate geologist, oil and gas; Bradford Willard, associate geologist, paleontology; Charles K. Graeber, associate geologist, mineralogy and areal geology; Forrest T. Moyer, assistant geologist, areal geology; W. O. Hickok, 4th, assistant geologist, areal geology and metals; M. N. Shaffner, technical assistant.

Industrial and Engineering Chemistry writes that at the Tenth Conference of the International Union of Chemistry, held at Liége in September, 1930, the committee on thermochemical data, formed in 1925 for a limited time, was replaced by the standing committee on thermochemistry, which includes the following: L. Keffler, Great Britain; C. Matignon, France; W. A. Roth, Germany; F. Swarts, Belgium; W. Swietoslawski, chairman, Poland; P. E. Verkade, Holland, and E. W. Washburn, United States. One of the main functions of that committee consists in the preparation of an International Table of Thermochemical Data, to be published under the patronage of the International Union of Chemistry under the same conditions as the International Tables of Atomic Weights. Authors of papers connected with thermochemistry and published within the last five years are requested to send two copies to the secretary of the committee, L. Keffler, Thermochemical Laboratory, University of Liverpool.

A DISPATCH to *The New York Times* from Paris reports that a decree creating the Superior Council for Scientific Research was signed by President Lebrun on April 14. The council will resemble France's Superior Council of Public Instruction and will coordinate scientific organizations and facilitate research in pure science. It will have eight divisions covering mathematical, mechanical, statistical, astronomical, physical, chemical, biological, natural, historical, philosophical and social sciences.

As a result of its recent petition the council of the Institute of Marine Engineers have received official information that King George has approved the grant of a charter to the institute. The attainment of this distinction follows closely on the forty-fourth anniversary of the foundation of the institute, in 1889. To-day the membership amounts to 3,550, including over 2,800 corporate members, among whom are many of the foremost marine engineers in Great Britain and the Dominions. The King became patron of the institute in 1918. The grant of the Royal Charter signifies recognition of the institute's record of work and achievement and affirms its status as the representative organization of the marine engineering profession.

THE Yosemite School of Field Natural History will be held in the Yosemite National Park from June 26 to August 11. The headquarters of the school are at the Yosemite Museum, but the greater part of the time will be spent in field work.

THE new Saguaro National Monument in Arizona comprises about 60,000 acres, mainly within the Coronado National Forest, on the slopes of the Santa Catalina mountains about 25 miles northeast of Tucson. It was created a National Monument by proclamation of President Hoover on March 1. Administration of the area will be in the hands of the Forest Service. The land will be protected from any use that would interfere with the preservation of the native flora, which is considered of great educational and scientific interest. Some of the specimens of the Giant Cactus on the area are believed to be more than 100 years old. Examples of European and American Indian and European archeological handiwork have been placed on display for the first time in Denver by the department of anthropology of the University of Denver. Pieces of Continental Paleolithic and Neolithic implements of the early man are arranged in the collection. Many of the specimens have been gathered personally by Dr. E. B. Renaud, head of the department of anthropology, during his archeological work in Spain and France. The greater portion of the exhibition is devoted, however, to the display of Indian native art and craftsmanship.

ACCORDING to the *Journal* of the American Medical Association, the Deutsche Gesellschaft für Kinderheilkunde, at its meeting in Dresden in September, 1931, expressed in a proclamation the fear that the long-continued economic crisis might cause a general weakening of resistance to disease in the oncoming generation. Observations made during the war show that children suffer the most from inadequate nutrition. For that reason, Drs. Gottlieb and Stransky, of the Vienna Public Health Service, examined 800 young children, establishing the weight of each child. They report in an article in the *Klinische Wochenschrift* that the number of underweight children in families that had been at least a year without a definite source of income was considerably higher than the number of children showing overweight. Among the children of employed parents, however, the number showing overweight was more than twice as large as the number presenting underweight. The children of the un-

employed, ranging between 2 and 4 years of age, show an especially large number who are underweight. In children 5 and 6 years old, the differences are not so marked.

Nature reports that at a recent meeting of the Industrial Advisory Committee of the Ross Institute, London, reports were received of the over-seas activities of the institute. Seven research centers in Assam and northern Bengal have been opened, and anti-malarial work and the testing of new drugs for the treatment of malaria have been pursued there and in Rhodesia and East and South Africa. In the Assam tea gardens, anti-malarial work has resulted in much improved health, for in 1930 among a population of 13,248 the admissions to hospital were 23,226, but in 1932 with a slightly larger population the admissions were reduced to 15,141. A standard oil mixture for killing mosquito larvae has been devised in conjunction with the Burma-Shell group. The health among lead miners in Yugoslavia was investigated and a health scheme was formulated and is now in operation. At the conclusion of the proceedings, Mr. Still and Sir Malcolm Watson addressed the meeting on the subject of yellow fever. Now that travel by aeroplane is so rapid, the grave danger that infection may be carried from the yellow fever zone in West Africa to East Africa and Asia, which would be followed with disastrous consequences, was emphasized.

DISCUSSION

ZOOLOGICAL NOMENCLATURE

PROFESSOR A. S. PEARSE, of Duke University, has recently contributed to SCIENCE[1] a number of thought-provoking reviews of recent text-books of zoology.

Professor Pearse makes, rather dogmatically, two statements in his reviews that to the taxonomist stand out as though they were printed in red ink and, though they are of distinctly minor importance, are as startlingly incongruent with the established formalities of nomenclature as red ink would be on a page of SCIENCE.

Professor Pearse makes the statement that "the scientific name of an animal consists of the genus, species *and the name of the author.*"[2] (The italics are Professor Pearse's). Had Professor Pearse said that the name of the author should be *appended* to the scientific name of an animal at least once in the publication using the name, one could agree with him, and might even walk with the International Commission on Zoological Nomenclature and add that the date of the proposal or some other clue to the original use of the name might also appear to advantage.[3]

Article 2 of the International Rules of Zoological Nomenclature states that "the scientific designation of animals is uninomial for subgenera and all higher groups, binomial for species, and trinomial for subspecies." Article 22 reads in part as follows (there is no need of quoting it in full): "If it is desired to cite the author's name, this should follow the scientific name without interposition of any mark of punctuation;—"[4] If the author's name is a *part* of the scientific name, as Professor Pearse contends, how is it possible for it to *follow* the scientific name? How can the part follow the whole?

Professor Pearse at another place[5] makes the following comment: "Evidently the writer disapproves of the modern tendency to begin even generic names with small letters, —" Let us refer to the Code. Article 8 reads: "A generic name must consist of a single word, simple or compound, written with a capital initial letter—."

Of course, a word may be used in more than one sense. The word felis, for instance, may be used as a formal scientific name, in which case it is properly capitalized. Also it may be used as a common noun, just as is its English equivalent, cat. In the latter usage it is not capitalized. Can it be this that Professor Pearse means? If so, he fails to make himself clear and has no need to appeal to a non-existent "modern tendency" for support of what has always been good usage.

Any tendency, however trivial, to flout the International Rules, the only hope we have for ultimate stability in zoological nomenclature, should bring a vigorous protest, even though the protestee is one as eminent and respected as Professor Pearse. Indeed, the more eminent the offender, the more necessary the protest.

J. BROOKES KNIGHT

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[1] SCIENCE, n. s., 77: 169–172.

[2] *Loc. cit.*, p. 170, first paragraph.

[3] See resolution of the International Commission on Zoological Nomenclature at Budapest, 1927, as published in U. S. Public Health Service, Public Health Reports, Oct. 28, 1927, pp. 2639–2640.

[4] International Rules of Zoological Nomenclature; Proc. Biological Society of Washington, volume 39, pp. 75–104.

THE INVOLVED GENETICS OF FISH

THE recent paper by Hubbs and Hubbs on "Apparent Parthenogenesis in Nature, in a Form of Fish of Hybrid Origin"[1] is of great interest to any one concerned with the extremely puzzling phenomena of ichthyological genetics. The matter is puzzling for the reason that although some crosses behave in normal Mendelian fashion, other crosses, like those

[5] *Loc. cit.*, p. 170, second column, first paragraph.

[1] SCIENCE, n. s., 76: 628. 1932.

recorded by Hubbs and Hubbs, refuse to conform to anything that the geneticist seems able to explain in the light of his studies with fruit-flies, birds or mammals.

For years the writer has bred tropical fish as a hobby and now has aquaria and indoor heated pools totaling 2,500 gallons capacity, with a number of sorts of hybrids under observation. Some of the facts connected therewith are worth recording.

First it should be stated that the commonest cross attempted in domestication is that of a male platy (*Platypoecilus*) of one or another of the developed color phases, with a female swordtail (*Xiphophorus helleri*). In the absence of live food, at least, the young hybrids are not produced as freely as those of pure lineage, but the former are all different from either parent, with size of mother and with color approaching or surpassing that of the father. These hybrids are known as "black helleris," "red helleris" or similarly according to color. At least when a female black helleri is mated to a pure male swordtail, approximately three quarters of the resultant young will be colorless like the father and one quarter black like the hybrid mother. The genetics of some of these various hybrids are extremely difficult to investigate, for many of them are sterile, and it is even claimed that males of some of the crosses are always so.

Hubbs and Hubbs found that when males of either *Mollienisia latipinna* or *M. sphenops* are mated with females of a hybrid between the two, which is a form currently known as *M. formosa,* all the offspring are always *formosa* in type. In other words, the hybrid characters are inherited by the young from the mother in a block, without respect to dissimilar paternity. And the offspring are invariably female. In this connection, however, the authors state that "the consistent and abundant production of purely matroclinous and constantly female offspring by this hybrid form of fish finds its most plausible explanation as parthenogenesis. It is apparently not a spontaneous parthenogenesis, since many controls, unmated, have shown no indication of becoming pregnant. We provisionally assume that we are probably dealing with a case of gynogenesis . . . a condition recorded as naturally occurring among certain invertebrates." Comment upon the above may be divided into three headings as follows:

(a) It is unwise to intrude the suggestion of parthenogenesis, even of a modified sort, into vertebrate literature. The phenomenon is so at variance with what is known and believed about vertebrate development that I am sure no vertebrate morphologist would admit for a moment that the natural development from egg to sexual maturity of an individual vertebrate without direct inclusion of the male element is within the realms of probability. Certainly extremely convincing cytological evidence would be necessary and the experiments verified several times.

(b) The fact that all the hybrids of *Mollienisia* produced were female appears to be ascribable in this instance, perhaps, to a sex-linked lethal factor acting on male eggs, or possibly to some type of non-disjunction. In this connection it may be mentioned that a yellow (mutant ?) strain of *Xiphophorus,* developed in domestication and known as the golden swordtail, consistently produces two or three times as many females as males, and the case of the *Mollienisia* may be an instance of this factor carried to an extreme.

(c) The matroclinous character of the offspring can involve no argument in favor of parthenogenesis, for I can cite reverse evidence, of a patroclinous nature, as follows: I have a strain of hybrids produced by crossing a male black platy (*Platypoecilus*) with a female of the golden swordtail strain of *Xiphophorus,* which are large, spectacular fish, mostly black but with many spots and blotches of green and orange. Apparently all individuals of this hybrid or at least a large proportion of them, are fertile, and when bred to one another they behave as a true species. In other words all the young of the second generation resemble their parents rather than either of the grandparents. So far so good, with nothing very remarkable. But when a male of this hybrid strain is mated with a female of pure strain green swordtail (*Xiphophorus helleri*), none of the young will be of dull color like the mother but all blackish like the hybrid father. This patroclinous inheritance has been tested in a number of individuals and litters. I have no doubt that it will hold throughout successive generations, but for proof or disproof of this assumption sufficient time has not yet elapsed.

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NOTE ON THE LIFE-CYCLE OF ECTOCARPUS SILICULOSUS DILLW.

THE generally accepted view that the plurilocular sporangia of *Ectocarpus siliculosus* produce gametes is based primarily on the classical work of Berthold[1] at Naples. His results have been confirmed by Oltmanns, Hartman, and, more recently, by Knight.[2] Knight demonstrated also that all the plants of this species that she found at Naples had a haploid soma.

[1] G. Berthold, "Die geschlechtliche Fortpflanzung der eigentlichen Phaeosporen," *Mitt. a. d. Zool. Stat. z. Neapel,* II. 1881.

[2] M. Knight, "Studies in the Ectocarpaceae. II. The Life-History and Cytology of Ectocarpus siliculosus, Dillw." *Trans. of the Royal Society of Edinburgh,* Vol. LVI. 1929.

Knight, on the other hand, found that all the plants of *E. siliculosus* studied by her at the Port Erin Biological Station have a diploid soma and bear both plurilocular and unilocular sporangia on the same plant. The plurilocular sporangia in this locality produce diploid zoospores. In the unilocular sporangium, however, the first nuclear division is a reduction division, and the haploid zoids from this structure are gametes which fuse in pairs. At Port Erin, she states, no alternation of generations occurs, and the diploid phase is the only one in the life-cycle.

The fact that zoids from plurilocular sporangia may at times act like zoospores has long been known; and the work of Knight suggests that in such cases they came from diploid plants. The zoids from unilocular sporangia have always been regarded as zoospores; and Knight is the only author who has found them sometimes behaving like gametes.

From aquarium cultures made at Naples, Berthold obtained plantlets that bore both plurilocular and unilocular sporangia on the same plant. The precise origin of the young plants in question was not determined. Berthold suggested that they may have come from zygotes. Since, however, unfertilized gametes, which he had already found to be capable of parthenogenetic development, were present in these aquaria we must keep in mind also the possibility that these in reality may have given rise to the small plants. Berthold also did not learn the function of the zoids from these cultured plants. Although he raised plants with unilocular sporangia in culture, he makes no mention in the text of finding these in the sea at Naples. (The plant shown in his Fig. 8 is referred to as having been found in the open). Knight states positively that she was unable to find unilocular sporangia there after careful search. The part that is played by unilocular sporangia in the normal life-history of this species at Naples therefore remained quite problematical.

It was apparent that further research on Ectocarpus was very essential. The facts that were known suggested the occurrence of an alternation of generations in this plant, but the evidence was far from adequate to substantiate this. It was also important to know whether the plants whose unilocular sporangia produce zoospores were diploid or whether unilocular sporangia may sometimes arise on haploid plants and give rise to zoospores which serve to multiply this generation.

This paper is a preliminary report of the results of an attempt to determine the course of the life-cycle of *Ectocarpus siliculosus* on the Atlantic coast of North America. The aim was to learn whether both haploid and diploid plants occur here and, if so, the rôle played by each in the life-cycle.

The material for this study was collected about Woods Hole, Massachusetts, during the summers of 1931 and 1932. All plants at Woods Hole itself were like those studied by Knight at Port Erin, since they were diploid and bore both kinds of sporangia. It was found, however, that the presumably haploid zoids of the unilocular sporangia as well as the diploid zoids of the plurilocular sporangia invariably germinate directly. That is, the zoids of the unilocular sporangia of these plants do not act like gametes, as Knight reported for the plants at Port Erin. Sexual plants as well as the asexual ones were found at Penikese, an island twenty miles from Woods Hole. The sexual plants are haploid and bear only plurilocular sporangia; their zoids serve as gametes, and they are distinctly dioecious. These sexual plants are therefore like those found at Naples. Parthenogenetic development of both male and female gametes occurs.

The cytological studies thus far made indicate that the number of chromosomes in asexual plants, with both kinds of sporangia, is twice as large as that found in the sexual plants, which bear plurilocular sporangia only.

The life-cycle of *E. siliculosus* near Woods Hole therefore exhibits a definite alternation of generations. Diploid asexual plants with both unilocular and plurilocular sporangia produce, in the plurilocular sporangia, diploid zoids which develop directly into other diploid plants. The first division of the nucleus in the unilocular sporangium is presumably a reduction division such as Knight found. The haploid zoids produced in this structure germinate to form haploid sexual plants. The haploid sexual plants are dioecious and produce gametes in plurilocular sporangia. After the fusion of these gametes in pairs the zygotes develop into diploid asexual plants and thus complete the cycle. The haploid sexual generation propagates itself by the parthenogenetic development of unfertilized gametes.

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ON THE SCIENTIFIC NAME OF THE WEBBING CLOTHES MOTH

THE webbing or common clothes moth, *Tineola bisselliella,* was first described by Hummel in 1823 (Essais Entomologiques 3: 13). In spite of the fact that the specific name was spelled with two s's in the original description, only one s is used by most writers at the present time. This is true of authors in Europe as well as of those in this country. Dyar[1] and Walsingham,[2] however, both spell the name with two s's.

The mistake in spelling is probably due to the fact that few writers have had an opportunity to see Hum-

[1] *U. S. Nat. Mus. Bul.,* 52: 570, 1902.
[2] *Zool. Soc. London, Proc.,* 1907, p. 1026, 1908.

mel's original description. The publication, "Essais Entomologiques," Nos. 1 to 7, was printed in St. Petersburg and was evidently issued in installments from 1822 to 1829. According to the Union list of serials in libraries of the United States and Canada, only three institutions have copies, and none of them owns the complete work. The Museum of Comparative Zoology (Cambridge) is listed as having Nos. 4 and 6; the Academy of Natural Sciences (Philadelphia) Nos. 4 to 7; and the American Philosophical Society (Philadelphia) No. 6.

The department of entomology at Cornell University has the good fortune to own all seven numbers of these interesting essays. On the inside of the front cover appears the following statement: "A very rare work. This copy contains No. VII, of which Hagen observed, "so excessively rare as scarcely to be known."" In Hagen's "Bibliotheca Entomologica" (1862, Vol. 1, p. 391) under the title, "Essais Entomologiques" he says, "Die Essais sind nicht häufig; No. 7 sogar äusserst selten und kaum gekannt."

Hummel's original description of the webbing clothes moth, in this rare and interesting publication, is written in Latin and is followed by a brief statement in French regarding the habits of the insect. Suggestions are also given for controlling the pest, especially in furniture. Preceding the description is the scientific name, *Tinea bisselliella,* followed by an asterisk which refers to a footnote at the bottom of the page. The footnote reads, "Du mot latin 'bisselium,' canapé." But Hummel may not have been as well versed in the classics as he was in entomology, for his spelling of the Latin word is incorrect. The word "bisellium" has but one s. A Latin lexicon gives the following definition: "Bisellium, a splendid ornamental seat of honor (so called because there was room for two persons upon it, although only one sat thereon). . . ."

When Zeller[3] wrote a more extensive description of this insect he dropped the second s in *bisselliella.* Perhaps Zeller was a better student of the classics than Hummel. In 1853 Herrich-Schäffer placed the species in the genus *Tineola* and he also used one s. Walsingham[2] criticizes Zeller's spelling and calls attention to the fact that Hummel used two s's.

According to the rules of priority, a name must stand as published in the original description. Therefore, although the Latin word was misspelled by Hummel, the mistake must stand and the specific name of the webbing clothes moth must remain *bisselliella.*

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[3] *Linnaea Entomologica,* 6: 166, 1852.
[4] *Syst. Bearb. Schmett. Eur.,* 5: 81, 1853.

HUMAN NECROBACILLOSIS

NECROBACILLOSIS is an acute infectious disease due to *Actinomyces necrophorus* Löffler. This condition was probably first noticed by Dammann, in 1870, in diphtheritic infections in calves. Schmorl (1891) reported a fatal enzootic occurring the previous year among his laboratory rabbits. *A. necrophorus* was isolated from the caseonecrotic lesions. Schmorl and one of his assistants each had a small abscess on one finger from handling these rabbits. Stained smears of the pus showed the characteristic gram-negative, beaded bacillus. In 1910, the writer isolated *A. necrophorus* from the lesions on the hand of a veterinary inspector.

Following the above reports of human necrobacillosis, the literature contains cases of pseudodiphtheria, infections of the arm, abscesses and necrosis of the tissues of the hip joint, retropharyngeal abscess with gangrene and extension into the perithracheal and subcutaneous tissue and mediastinum. Two deaths occurred in the series. Recently the writer isolated *A. necrophorus* from a lung abscess of man.

Among the principal pathologic conditions (other than man) in which *A. necrophorus* is found may be mentioned lip and leg ulceration of sheep, gangrenous dermatitis of horses and mules, necrotic stomatitis in cattle and multiple necrotic foci in the livers of cattle and hogs. Spontaneous necrobacillosis has been observed in nineteen different species of animals.

A. necrophorus is a pleomorphic anaerobe. It may vary from cocci to long filaments, and from solid stained rods to filaments with granules. Spores are not formed. It is gram-negative.

Several mediums have been used for the growth of *A. necrophorus,* but a medium of veal infusion, peptone and cystine is very satisfactory. For primary isolation serum should be added.

To obtain the woolly colonies in agar stab cultures, one must not use too stiff an agar, 0.3 per cent. being satisfactory for the demonstration.

As *A. necrophorus* does not produce group agglutinins the agglutination reaction can not be used for the differentiation of this organism.

Hemolysis is another property that is variable; some authors state that necrophorus is strongly hemolytic, while others state that it is non-hemolytic.

The fermentation of carbohydrates is, likewise, at variance.

Subcutaneous injection of the microorganism into the rabbit produces an area of necrosis and, after a time, invasion of the internal organs, although some strains do not produce anything beyond the local lesion, which heals.

The difficulty of isolation of anaerobes in general, and of *A. necrophorus* in particular, is probably re-

sponsible for the low record of human cases of necrobacillosis. Material containing a pleomorphic bacillus with beaded threads should be grown under anaerobic conditions, in or on mediums containing serum. Anaerobic cultures of the blood should be made in all cases of infectious jaundice. Some of the tubercular hips are, in all probability, necrophorus infections.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD AND THE APPARATUS FOR THE STUDY OF PERMEABILITY OF GASES THROUGH THE BIRD'S EGG-SHELL

OUR previous study[1] of such physical factors of the eggshell as breaking strength, thickness, and relative number and size of pores (observed microscopically) convinced us that the eggshell has definite characteristics peculiar to the species of bird, the flock of birds of the same species, the birds of the same flock, and in a less degree to the eggs laid by the same individual.

Yet the structural and physical properties of the eggshell are found to be very important in regard to the storage and preservation of eggs for future use. For example, an egg with a thin or very porous eggshell would likely more rapidly evaporate or lose moisture, more readily absorb outside odors and gases, and allow more easy penetration by micro-organisms. All these conditions eventually would lead to some changes in physical state and possibly in chemical composition of the egg-contents and thus soon to a decrease in the nutritive value of the eggs.

Furthermore, the structural and physical properties of the eggshell have their biological significance. There is a constant loss of moisture and interchange of respiratory gases through the eggshell during the incubation. This rate of interchange of gases, or absorption of oxygen and elimination of carbon dioxide, is gradually increasing in volume per time with the embryonic growth and development. On the other hand, the eggshell furnishes the largest portion of the calcium needed for the building up of the skeleton of the developing embryo, thus leading to some changes in its physical properties. An egg with extremely thin or thick shell may therefore present an important biological problem in relation to the developing embryo.

It is evident, however, that from both the economic and biological points of view a reliable quantitative direct method of measuring the quality of a bird's eggshell would be very desirable.

In view of the above facts, during the past three years, our laboratory of experimental embryology has developed and improved primarily for scientific use a special electric apparatus for the direct and accurate measurement of the permeability of the bird's eggshell to various gases.

The apparatus, as shown diagrammatically in the accompanying Fig. 1, operates on the principle of

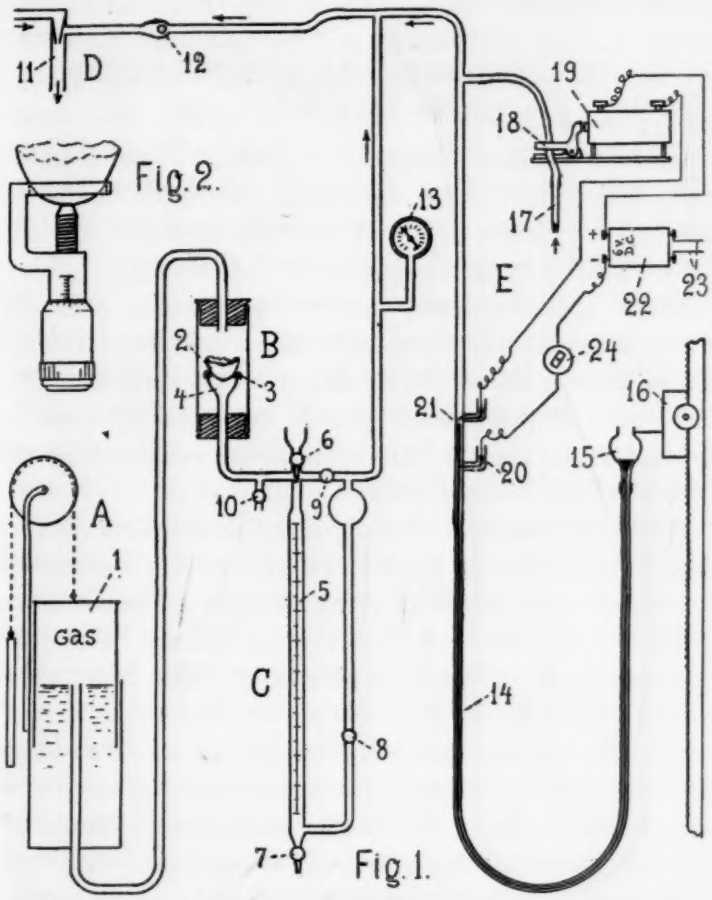

FIG. 1. A diagram of the apparatus for measurement of the permeability of a gas through the bird's eggshell. A, gas holder (1) with a gas; B, eggshell chamber, shown with eggshell (2), rubber gasket (3), and funnel (4) of one-inch inside diameter; C, micro-gas meter, consisting of a 50-cc. burette (5) funnel with glass stopper (6) for refilling of the burette (5) with water, drain stopcock (7), control stopcock (8), set up stopcock (9), vacuum relief stopcock (10); D, vacuum pump, including water suction pump (11) and back pressure valve (12); E, automatic vacuum controlling mechanism, consisting of vacuum gauge (13), adjustable monometer (14) with level bulb (15) and slide with screw (16), capillary tube (17), lever (18), induction coil (19), fixed contact point of the monometer (20), break point of the monometer (21), rectifying transformer (22), line of alternating current (23), and switch for the vacuum-controlling mechanism (24).

FIG. 2. A micrometric spherometer shown with a portion of eggshell, the surface of which is to be measured.

[1] A. L. Romanoff, "Study of the Physical Properties of the Hen's Eggshell in Relation to the Function of Shell-secretory Glands," *Biol. Bull.*, 56: 351–356, 1929.

suction of the gas in question through the portion of the eggshell (B-2). The passing gas is measured in an especially designed micro-gas meter (C) and a constant predetermined vacuum is maintained by an adjustable self-controlled monometer (E), operated automatically by electricity.

The volume of gas which passes through the portion of eggshell is read in cc./min./sq. cm. The data are obtained from the table of calculated and corrected values obtained after measurement of the curvature of eggshell by a special micrometric spherometer (Fig. 2).

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A METHOD FOR THE PREPARATION OF FOSSILS

IT is a common practise of paleontologists, when preparing fossil shells, to cement the specimen to be cleaned in plaster of Paris, thereby insuring rigidity and stability against the strain of cleaning. This method is particularly useful in cleaning delicate shells otherwise too fragile to allow complete freeing from their matrix. There is a distinct disadvantage, however, in the use of plaster of Paris because it forms a permanent base concealing one surface of the fossil shell from view.

While preparing Paleozoic star-fishes, echinoids and brachiopods for study, the writer found paraffine to be much more desirable than plaster of Paris as a support for the fossil during cleaning. The advantage of paraffine over plaster of Paris is its easy removability from the cleaned specimen, so that a free valve or star-fish, etc., is obtained as a result of the cleaning. After the matrix has been cleaned from one surface of the fossil, the specimen is cemented in wax poured into a box or other container, with the cleaned surface down in the wax. The matrix is then worked off the opposite surface, leaving a completely cleaned specimen embedded in the wax. For greater rigidity, the specimen and its paraffine base can be cemented in plaster. After cleaning, the plaster is broken away from the wax base and the paraffine dissolved away by xylol or cotton soaked in xylol for very delicate shells. In this way a number of Paleozoic star-fishes of all sizes have been freed completely from their matrix, and many rare and new brachiopod shells have been cleaned internally and externally.

The method has proved useful in preparing such delicate structures as the loops of the Terebratulidae. The loop is exposed on one side, then wax is poured on this exposed surface of the loop. This gives a rigid base which will allow working the matrix away from the loop from the other side. Dissolving the paraffine leaves a free loop.

In order to prevent the paraffine from softening during the cleaning, which is commonly carried out near a strong, hot light under a binocular microscope, it is frequently necessary to plunge the embedded specimen into cold water. As long as the wax is kept cool and stiff it is quite as safe a bedding medium as plaster of Paris. It is sometimes desirable to perform the entire cleaning process under water. Besides keeping the wax stiff, this has the advantage of making a strong contrast between shell and matrix.

By the above method it is possible to secure the interior of either valve of brachiopods in which both valves are in conjunction. The particular valve desired is cemented in the paraffine base. Then the valve whose interior is not wanted is ground away and cleaning of the desired valve progresses.

In making preparations such as those described above, the dental engine is very useful, but for the most delicate work against the shell, needles sharpened to a chisel edge are the best tools.

G. ARTHUR COOPER

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SPECIAL ARTICLES

THE UTILIZATION OF ADSORBED IONS BY PLANTS[1]

RESTRICTED Brownian movement of ions is one of the great differences between a nutrient solution and a natural soil. In culture solutions the nutrient ions are free to move (diffusible), while in soils they are "adsorbed" on colloidal particles, fixed in crystals and thus exist under conditions of constraint.

In the study of the liberation of adsorbed ions by the plant itself it is necessary that at the outset the nutrient ions be present in adsorbed form only. Otherwise the free ions in the liquid phase could replace the adsorbed elements (ionic exchange)[2] and the problem would approach a mere nutrient solution experiment. Soybean plants were grown in systems containing but *one nutrient ion* (calcium), which for purposes of comparison was either free in solution or adsorbed on colloids or fixed in the interior of crystals.

EXPERIMENTAL METHOD

(a) *Free calcium ions in the soil solution.* Ca-acetate and $CaCl_2$ are very soluble. $CaCO_3$ furnishes Ca ions according to the CO_2 content of the system.

(b) *Adsorbed Ca ions on colloids.* Prolonged electrodialyses of soil colloids removes all free and adsorbed

[1] Missouri Agricultural Experiment Station, Journal Series No. 329.

[2] H. Jenny, *Jour. Phys. Chem.*, 36: 2217–2258, 1932.

ions and the resulting H-systems can be transformed into pure Ca-colloids by addition of $Ca(OH)_2$. These adsorbed Ca ions are all exchangeable. Putnam clay and colloidal bentonite were thus treated. Artificial zeolite (permutite) was prepared as described previously.[3]

(c) *Non-exchangeable Ca ions in the interior of close packed crystal lattices.* Anorthite, a Ca-alumino silicate, was ground in a mortar and—as all the other dried colloids—passed through a 100 mesh sieve. Only those Ca ions seated in the outer surface of the mineral particles are exchangeable.

Soybean seedlings were put into nursery bottles (four plants) containing a uniform mixture of 300 grams of purified quartz sand and various amounts of the above Ca-compounds. All systems had an initial pH of 7. The water content was adjusted twice daily to 20 per cent. of the weight.

Comparison Between Adsorbed Ions and Non-exchangeable Ions

Fig. 1 (solid lines) shows that the soybean plant can live and do well in media which contain mainly

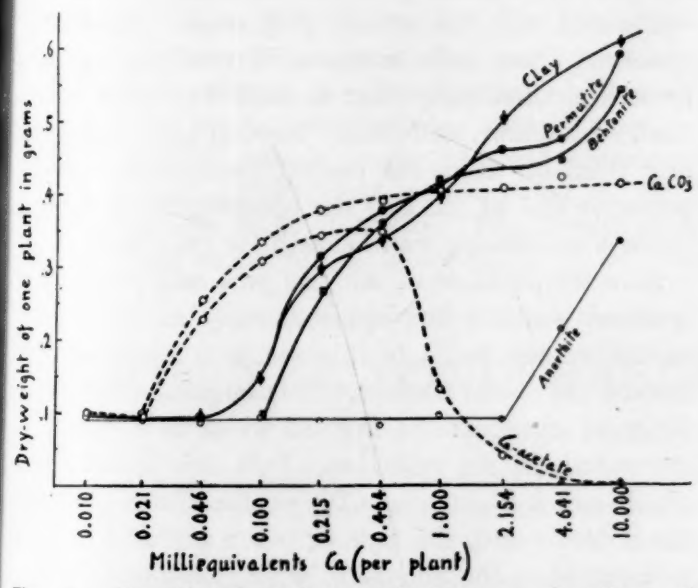

FIG. 1. Growth of soybean plants as a function of amount and form of calcium in the medium.

adsorbed Ca ions. This holds true even for sterile systems, in absence of microorganisms. On the other hand, Ca ions in the interior of crystal lattices can not be utilized or only with difficulty. The growth observed on anorthite at very high calcium concentrations is very likely due to exchangeable surface cations resulting from the grinding process of the mineral.

Comparison between Adsorbed Ions and Free Ions

Under low calcium concentrations the plant yields are much higher for the "free Ca" system than for the "adsorbed" one, indicating that the plant encounters considerable difficulty in obtaining the adsorbed ions. The situation becomes entirely reversed at higher Ca concentrations where, most strikingly, the plants grow best on adsorbed ions, surpassing even the $CaCO_3$ system. This indicates a specific behavior of adsorbed ions in regard to plant growth.

The Mechanism of Liberation of Adsorbed Ions by Plants

Fig. 1 demonstrates that plants are able to free adsorbed ions. This is by no means a simple process. The Ca-colloids used form no true solutions, and the concept of the solubility product can not be applied. In a strictly physico-chemical sense, the Ca-colloids are practically insoluble.

One might conceive the picture that the plant simply removes the adsorbed Ca, attracts it, pulls it away, so to speak. But in this case free electric charges would be left on the particle, leading to enormous potential differences in the electric double layer. It would be difficult to reconcile such a mechanism with the known laws of electrostatics.

It is possible, however, to have a liberation of adsorbed Ca by means of ionic exchange. In such a case—where hydrolysis is negligible—the plant would have to excrete cations other than Ca and these ions would replace the adsorbed calcium. The excreted cations should be found on the colloid. The following experiment is interesting in this respect.

Thirty soybean seedlings were transplanted into 100 cc of 2.50 per cent. pure Ca-clay suspension having a pH of 6.30 and containing 1.500 milliequivalents of adsorbed Ca ions. The plants were harvested 35 days later and after subtracting the original Ca content of the sprouted beans (0.0280 minus 0.0076g. Ca) it appeared *that the plants had removed from the clay 1.020 milliequivalents Ca.* The reaction of the sol had dropped from pH 6.30 to 4.32. Evidently the colloidal particles contained now numerous H ions. These were determined by titration with $Ca(OH)_2$ and it was found that *the clay carried 0.948 milliequivalents H ions which it did not possess at the beginning of the experiment.* In other words, it appears that an exchange has taken place which is stoichiometrical (93 per cent.) within the limits of the present technique. These data and other unpublished trials suggest that *the plant has excreted H ions which have replaced the Ca ions on the clay enabling them to enter the plant.* For every Ca ion that went into the plant, two hydrogen ions are found on the colloidal particles.

Practical Conclusions

(1) It has been demonstrated quantitatively that total analysis of the soil is a poor indicator of soil fertility because the determination does not differentiate between adsorbed and non-exchangeable lattice ions.

[3] H. Jenny, *Kolloid. chem. Beih.* 23: 428–472, 1927.

(2) Since the plant can feed successfully on adsorbed ions, it appears that the significance of the "soil solution" has been overestimated.

(3) The solubility concept is not adequate enough to account for plant growth in soils of humid regions. Ionic exchange must be taken into consideration.

(4) The study of the adsorbed (exchangeable) ions in the soil offers great possibilities for a better understanding of many soil-plant relationships and soil fertility problems (*e.g.*, utilization of fertilizers, distribution of pasture vegetation, soil acidity, activity of soil microorganisms).

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OBSERVATIONS ON EARLY DEVELOPMENTAL PROCESSES IN THE LIVING EGG OF DROSOPHILA

DUE to the fact that the egg of Drosophila is covered by a semi-opaque chorionic membrane, our knowledge of the course and rate of early developmental processes has, up to the present time, been gained only by a study of preserved material, prepared by means of the usual cytological technique. Such a study has not only been a laborious one because of the inherent limitations of a method requiring the reconstruction of a three-dimensional object from serial sections, but it has also been open to error because of the uncertainty as to the age of an egg at the time of deposition. This latter source of difficulty has heretofore been overcome to a large extent by keeping under observation a laying female, rejecting the first eggs laid, and carefully timing eggs laid subsequently. Under suitable conditions, fertilized eggs are not retained by the female for more than twenty minutes.

During the past summer, we found a simple and satisfactory method for observing early embryonic development in the living egg. An egg, firmly imbedded in the agar in which it has been laid, or fastened to a glass slide by a film of Ambroid cement, may be dechorionated with fine, sharp needles under a binocular microscope. It is then mounted in water, and a thin coverslip, supported by bits of glass, placed over it. As the inner membranes are transparent, developmental changes may be followed under high powers, though the definition of the earliest cleavage figures is somewhat obscured by the overlying yolk granules. While under observation, the egg can be rolled about by pushing the coverlip slightly from side to side.

In the early egg, the protoplasmic islands around the first cleavage nuclei appear as lighter spherical regions well marked off from the dense surrounding yolk. As cleavage proceeds, these islands increase in number and decrease in size, giving the egg a "dappled" appearance. Soon a lighter grayish cap arises at the posterior end, presaging the formation of the pole or germ-tract cells. These are pushed out as large buds, which then constrict off from the underlying ooplasm with great rapidity, forming a conspicuous layer; this is separated from the adjacent ooplasm by a clear fluid-filled space. At a temperature of 22° the pole cell formation is approximately complete within 20 to 30 minutes after the first bud forms. Protoplasmic islands containing the yolk nuclei now remain in the center, while the cleavage nuclei migrate to the periphery of the egg to form the blastoderm. Here they push out bud-like prominences over the entire surface, except in the region of the pole cells. This gives the cleaving egg a morula-like appearance, which is most pronounced at the anterior end. Dividing walls can now be seen growing inward and enclosing each blastodermic nucleus in a cubical protoplasmic area which is still continuous with the central yolk mass. As cleavage proceeds, these cells increase in number, are compressed against each other so that they are now distinctly columnar, and finally develop inner walls cutting them off from the central protoplasm. At the posterior end of the egg the blastodermic layer next forms a continuous wall beneath the pole cells.

At a temperature of 22° the pole cells retain their terminal position for approximately an hour, when suddenly they begin to migrate with great rapidity toward the dorsal surface. This migration initiates a series of changes: the first of which is a dorsal invagination in the mid line. Into this invagination, which arises about one fifth of the distance toward the anterior end, the pole cells are pushed.[1] At the moment when the pole cells begin to descend into the cup-like invagination, the cells along the entire dorsal surface begin to group themselves into metameres. These are pronounced by the time the pole cells disappear within the dorsal invagination. At 22° C. the entire series of growth changes, including migration, invagination and metamere formation, occurs within the brief period of 10 to 15 minutes.

Cinematographic records of the processes described above as well as of subsequent embryological changes are now being made, and will serve as the basis for a more extensive report to be given later.

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[1] The force exerted seems to be due to a rapid upward growth of the ventral blastoderm. This point, however, needs further careful study.